Radiographic measurement of displacement in acetabular fractures: a systematic review of the literature

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Abstract: OBJECTIVES: To report methods of measurement of radiographic displacement and radiographic outcomes in acetabular fractures described in the literature. METHODS: A systematic review of the English literature was performed using EMBASE and Medline in August 2014. Inclusion criteria were studies of operatively treated acetabular fractures in adults with acute (<6 weeks) open reduction and internal fixation that reported radiographic outcomes. Exclusion criteria included case series with <10 patients, fractures managed >6 weeks from injury, acute total hip arthroplasty, periprosthetic fractures, time frame of radiographic outcomes not stated, missing radiographic outcome data, and non-English language articles. Basic information collected included journal, author, year published, number of fractures, and fracture types. Specific data collected included radiographic outcome data, method of measuring radiographic displacement, and methods of interpreting or categorizing radiographic outcomes. DATA SYNTHESIS: The number of reproducible radiographic measurement techniques (2/64) and previously described radiographic interpretation methods (4) were recorded. One radiographic reduction grading criterion (Matta) was used nearly universally in articles that used previously described criteria. Overall, 70% of articles using this criteria documented anatomic reductions. CONCLUSIONS: The current standard of measuring radiographic displacement in publications dealing with acetabulum fractures almost universally lacks basic description, making further scientific rigor, such as testing reproducibility, impossible. Further work is necessary to standardize radiographic measurement techniques, test their reproducibility, and qualify their validity or determine which measurements are important to clinical outcomes. LEVEL OF EVIDENCE: Diagnostic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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Radiographic Measurement of Displacement in Acetabular Fractures: A Systematic Review of the Literature

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Objectives: To report methods of measurement of radiographic displacement and radiographic outcomes in acetabular fractures described in the literature.

Methods: A systematic review of the English literature was performed using EMBASE and Medline in August 2014. Inclusion criteria were studies of operatively treated acetabular fractures in adults with acute (<6 weeks) open reduction and internal fixation that reported radiographic outcomes. Exclusion criteria included case series with <10 patients, fractures managed >6 weeks from injury, acute total hip arthroplasty, periprosthetic fractures, time frame of radiographic outcomes not stated, missing radiographic outcome data, and non–English language articles. Basic information collected included journal, author, year published, number of fractures, and fracture types. Specific data collected included radiographic outcome data, method of measuring radiographic displacement, and methods of interpreting or categorizing radiographic outcomes.

Data Synthesis: The number of reproducible radiographic measurement techniques (2/64) and previously described radiographic interpretation methods (4) were recorded. One radiographic reduction grading criterion (Matta) was used nearly universally in articles that used previously described criteria. Overall, 70% of articles using this criteria documented anatomic reductions.

Conclusions: The current standard of measuring radiographic displacement in publications dealing with acetabulum fractures almost universally lacks basic description, making further scientific rigor, such as testing reproducibility, impossible. Further work is necessary to standardize radiographic measurement techniques, test their reproducibility, and qualify their validity or determine which measurements are important to clinical outcomes.

Key Words: radiography, x-rays, displacement, reduction, acetabulum, acetabular, measurement techniques, fractures, outcomes

Level of Evidence: Diagnostic Level IV. See Instructions for Authors for a complete description of levels of evidence.

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INTRODUCTION

Fractures of the acetabulum are high-energy, potentially life-changing injuries. Management of these injuries is complex and remains challenging for experienced orthopaedic trauma surgeons.[1] It is well accepted in the literature and by experts in the field that anatomic reduction and stable fixation of these injuries is paramount in obtaining good outcomes after acetabular fractures.[1–3]

Outcomes in orthopaedic surgery have historically been evaluated with objective measures as proxies for general functional outcome; most commonly, these have been radiographic markers of displacement.[4] Although functional outcome measures are taking on a much larger role in research, radiographic outcomes remain important as orthopaedic surgeons continue to consistently measure intraoperative and postoperative success radiographically.[5] There has been an increasing effort to design and test outcome measures of all kinds that are both reliable and valid.[4] Because of the challenges with the standardization of radiographs and the reliability of commonly used measurements in radiographic assessment, radiographic measures and outcomes continue to pose a problem both clinically and in research.[5]

Patients with pelvic and acetabular fractures are often polytraumatized, and both the injuries and their treatments are fraught with complications.[1,2] This creates confounders in measuring outcomes; thus, the level of evidence in this area remains poor. The current literature allows, at best, a grade C recommendation.[5]

Most experts agree that the outcomes of acetabular fractures are directly related to the concentricity of the reduction of the hip and the reduction of the weight-bearing dome.[1–3,6] As a result, most authors have assessed fracture displacement and reduction radiographically as a proxy for functional outcome in pelvic and acetabular fractures. However, for any outcome measurement tool, reproducibility, reliability, and validity of these measurements are important in ensuring consistency of reported results.[7] To correlate these radiographic measurements with patient outcomes, surgeons must rely on the accuracy of those initial radiographic measurements. We have previously investigated this topic in the setting of pelvic ring disruptions, but no such work has been performed in acetabular fractures.[5,8]

Despite some generally accepted guidelines, no widely accepted standardized method for measuring displacement of acetabular fractures exists. Few have been described in the literature, and their reliability has not been tested. One of the most published authors on acetabular fractures has stated that the quality of the reduction of the weight-bearing dome is directly related to patient outcome.[6] However, a close review of that publication fails to show a specific description of how to measure the degree of fracture displacement before or after surgery, making interpretation of this article difficult both in research and clinically.

The goal of this systematic review is to examine the current literature as it pertains to radiographic displacement in acetabulum fracture and to find and describe the methods of measurement of radiographic displacement and methods of categorizing radiographic outcomes in acetabular fractures that have been used in the literature.

MATERIALS AND METHODS

We performed a systematic review of the literature using Medline and EMBASE, with the goal of finding all previously described methods of measurement of radiographic displacement of acetabular fractures. The search strategy and flowchart are depicted in Figure 1. Inclusion and exclusion criteria are as follows:

Inclusion Criteria

1. Case series, cohort studies, or clinical trials regarding orthopaedic treatment of traumatic adult acetabular fractures
2. Radiographic reduction outcome documented
3. Acute treatment (<6 weeks)
   - Open reduction and internal fixation of acetabulum
4. All cases managed operatively
5. Management by orthopaedic surgeon
6. Published in orthopaedic/trauma journal

Exclusion Criteria

1. Case reports or case series <10 patients
2. Outcomes of treatment of acetabular malunions or nonunions treated at >6 weeks after injury
3. Acute surgical treatment other than open reduction and internal fixation (ie, immediate total hip arthroplasty)
4. Time frame of outcome measurement not stated
5. Unable to isolate radiographic outcome in subset of patients
6. Review articles
7. Foreign language articles with no translation available

Two authors performed the systematic review independently. Results from all databases were combined, and duplicate titles were removed. Two reviewers assessed the articles at each stage of the filtering process (titles, abstracts, and full-length articles). At all but the final stage, disagreement led to inclusion. At the final stage of selection, disagreement was resolved by consensus.

After full-length articles to be included were selected, one author performed data extraction. Basic information extracted included title, year of publication, authors, journal

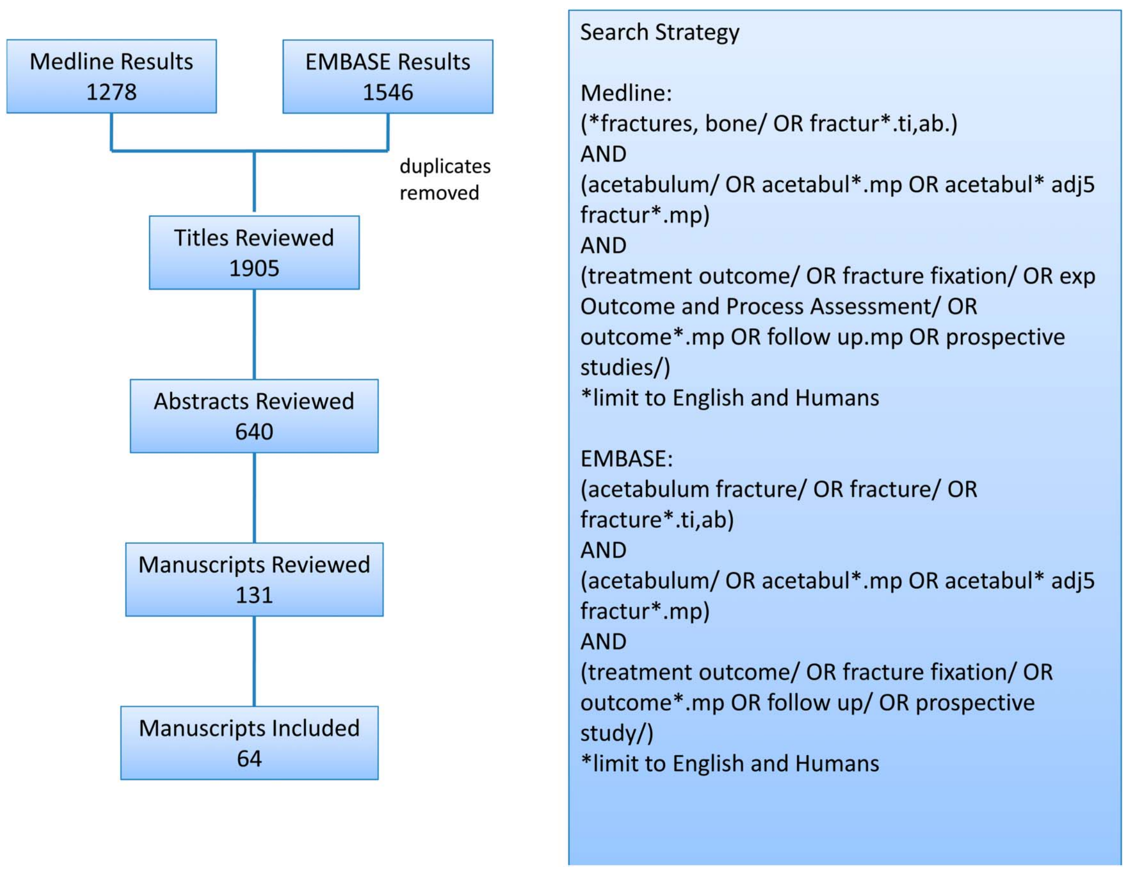

FIGURE 1. Search strategy and flowchart. **Editor's note:** A color image accompanies the online version of this article.

title, number of patients, and study design. Specific information extracted included types of fractures reported, method of determining radiographic outcome, any method of categorizing radiographic outcome, timing of surgery, and whether all cases were managed operatively.

RESULTS

Sixty-four articles met the inclusion criteria (Tables 1–3). Publication dates ranged from 1989 to 2014 and included 62 different first authors. The most frequent journals included were the *Journal of Orthopedic Trauma* (15), *Injury* (12), *Clinical Orthopedics and Related Research* (9), and the *Journal of Bone and Joint Surgery British* (8). A total of 4335 acetabular fractures with radiographic outcomes were reported on, and most studies included a variety of fracture patterns. In total, there were 1798 elementary (OTA 62.A1–62.B1) and 2537 associated (OTA 62.B2–62.C3) fractures included.[72,73]

Of the included articles, only 2 had clear written descriptions of the method used to measure radiographic displacement (Table 1). The remaining 62 articles did not use a clearly described measurement technique. Forty-seven articles used a previously described method of categorizing their radiographic displacement, almost universally the severity scale described by Matta[6] (Table 2). This scale classifies fractures into 4 categories based on any residual step in the radiographic reduction: anatomic (0–1 mm), imperfect (2–3 mm), poor (greater than 3 mm), or secondary surgical congruency (acetabulum anatomic but position of joint altered). No specific instruction on how to arrive at these measurements has been provided. In addition, this scale has changed over time, as earlier descriptions included only anatomic and satisfactory categories.[6] The remaining 16 articles used no described radiographic measurement technique or previously described scale (Table 3).

Borrelli et al describe a method of determining articular steps and gaps on plain radiographs.[9] They used a circular template that matched the arc of curvature of the intact portion of the weight-bearing dome of the acetabulum. This template was used to draw the location of the articular surface of the intact acetabulum on the injury radiographs. Steps and gaps were then measured relative to this line (Fig. 2).

Park et al[10] describe a similar method; however, no diagrammatic examples of the measurements were provided, which makes this method difficult to reproduce. A line was drawn that connected the fracture margin at the subchondral bone of the displaced fragment to the center of a circle drawn about the femoral head. Steps were measured as the distance between the subchondral bone of the fracture fragment and the point at which the described line intersected the circle around the femoral head. Gaps were measured as the distance between the described line and the subchondral bone of the intact acetabular dome.

Despite the lack of specific methods for radiographic measurement used by authors published in this area, there was generally favorable self-assessment of radiographic results by authors. The authors who reported results based on Matta's criteria reported only 225 poor results out of 3249 fractures (6.9%), whereas 70% of fracture reductions were deemed anatomic.

DISCUSSION

It is well agreed that the reduction of the weight-bearing dome of the acetabulum has a strong influence on patient outcomes. Despite this, few authors have described reproducible methods of measuring radiographic displacement. Although there is a commonly cited and discussed scale of radiographic displacement applied in articles and textbooks, this scale itself is not associated with a specifically described method of measuring radiographic displacement, whether by the original or by subsequent authors.[6] As such, despite the wide use of this scale, the lack of transparency and rigor in radiographic outcome determination by those who used it makes comparing outcomes between series impossible. The true degree to which residual articular incongruity affects outcomes also remains unclear, making evidence-based treatment recommendations in this injury difficult.

The necessary steps to determine that an outcome measurement is reliable, reproducible, and valid involve a vital first step of clear description of how to perform the measurement. Only then can reliability and reproducibility be tested. Once it has been determined that a measure is reproducible and reliable, the validity of the measure can also be tested. In the case of radiographic measurements, this would be testing radiographic displacement against some gold standard of outcome, such as functional outcome. Only after these steps have been taken, can real comparison across studies or confident conclusion formation from single studies takes place.[7]

In addition to the reduction criteria of Matta,[18] 2 other methods of interpreting the quality of radiographic reduction were referenced in the included articles. Helfet et al describe a grading scheme similar to Matta's criteria; however, there is

TABLE 1. Method of Radiographic Reduction Measurement Reported

Year	Journal	First Author	Number of Fractures	Fracture Types	Radiographic Outcome Grading Scale Used	Reported Radiographic Reduction Outcomes
2005	*Journal of Orthopaedic Trauma*	Borrelli[9]	15	8 simple, 7 complex	No	1 residual step, 6 residual gap
2013	*Hip International: The Journal of Clinical and Experimental Research on Hip Pathology and Therapy*	Park[10]	31	3 simple, 28 complex	Matta	20 anatomic, 9 imperfect, 2 poor

TABLE 2. Previously Reported Radiographic Reduction Scale Used

Year	Journal	First Author	Number of Fractures	Fracture Types	Radiographic Outcome Grading Scale Used	Reported Radiographic Reduction Outcomes
1989	*Clinical Orthopaedics and Related Research*	Goulet[11]	31	31 complex	Matta	26 anatomic, 3 satisfactory, 2 unsatisfactory
1990	*Journal of Orthopaedic Trauma*	Webb[12]	23	5 simple, 18 complex	Matta	22 anatomic, 1 unsatisfactory
1993	*Injury*	Brueton[13]	40	6 simple, 34 complex	Letournel and Judet (1981)	9 perfect/perfect, 6 almost perfect/almost perfect, 6 very good/imperfect, 3 very good/poor, 1 poor/poor, 1 secondary congruence
1993	*The Bone & Joint Journal*	Schmidt[14]	21	4 simple, 17 complex	Matta	18 satisfactory, 3 unsatisfactory
1994	*Clinical Orthopaedics and Related Research*	Cole[15]	55	15 simple, 40 complex	Matta	54 satisfactory, 1 unsatisfactory
1994	*Journal of Orthopaedic Trauma*	Wright[16]	87	41 simple, 46 complex	Matta (not cited)	35 anatomic, 40 satisfactory, 11 unsatisfactory
1995	*Injury*	Moroni[17]	18	18 complex	Matta	5 anatomic, 11 satisfactory, 2 unsatisfactory
1996	*The Journal of Bone and Joint Surgery. American*	Matta[18]	262	54 simple, 208 complex	Matta	185 anatomic, 52 imperfect, 18 poor, 7 secondary congruence
1998	*International Orthopaedics*	Fica[19]	84	33 simple, 51 complex	Matta	41 anatomic, 20 satisfactory, 23 unsatisfactory
2000	*European Journal of Orthopaedic Surgery & Traumatology*	Korovessis[20]	75	33 simple, 42 complex	Matta	60 anatomic, 9 imperfect, 6 poor
2000	*Clinical Orthopaedics and Related Research*	Moed[21]	94	94 simple	Matta	92 anatomic, 2 imperfect
2002	*Journal of Orthopaedic Trauma*	Starr[22]	43	2 simple, 41 complex	Helfet[9]	24 anatomic, 16 satisfactory, 3 poor
2002	*Journal of Orthopaedic Trauma*	Rice[23]	166	81 simple, 85 complex	Matta	145 anatomic, 25 imperfect, 4 poor, 6 secondary congruence
2002	*Acta Orthopaedica Scandinavica*	Kang[24]	21	4 simple, 17 complex	Matta	20 anatomic, 1 poor
2002	*The Journal of Bone and Joint Surgery. American*	Moed[25]	100	100 simple	Matta	97 anatomic, 3 imperfect
2002	*Journal of Orthopaedic Trauma*	Stockle[26]	50	11 simple, 39 complex	Matta	40 anatomic, 10 satisfactory
2003	*Clinical Orthopaedics and Related Research*	Mears[27]	424	119 simple, 305 complex	Matta	282 anatomic, 90 imperfect, 39 poor, 13 secondary congruence
2003	*The Journal of Bone and Joint Surgery. American*	Moed[28]	67	67 simple	Matta	65 anatomic, 2 imperfect
2003	*Injury*	Murphy[29]	180	84 simple, 96 complex	Matta	156 anatomic, 24 imperfect/poor
2004	*Archives of Orthopaedic and Trauma Surgery*	Kinik[30]	25	8 simple, 17 complex	Matta	17 anatomic, 2 imperfect, 5 poor, 1 secondary congruence
2006	*The Bone & Joint Journal*	Bhandari[31]	109	42 simple, 67 complex	Matta	96 anatomic, 12 imperfect, 1 poor
2006	*Journal of Orthopaedic Science*	Oh[32]	15	7 simple, 8 complex	Matta	6 anatomic, 5 imperfect, 4 poor
2007	*The Bone & Joint Journal*	Giannoudis[33]	29	29 simple	Matta	29 anatomic

TABLE 2. (*Continued*) Previously Reported Radiographic Reduction Scale Used

Year	Journal	First Author	Number of Fractures	Fracture Types	Radiographic Outcome Grading Scale Used	Reported Radiographic Reduction Outcomes
2007	*The Journal of Trauma*	Panagiotis[34]	75	34 simple, 41 complex	Matta	58 anatomic, 9 imperfect, 8 poor
2009	*The Bone & Joint Journal*	Giannoudis[35]	52	33 simple, 19 complex	Matta	43 anatomic, 9 imperfect
2010	*Journal of Orthopaedic Surgery*	Li[36]	37	37 simple	Matta	31 anatomic, 4 imperfect, 2 poor
2010	*The Journal of Trauma*	Negrin[37]	104	26 simple, 78 complex	Matta	67 anatomic, 23 imperfect, 14 poor
2010	*Journal of Orthopaedic Trauma*	Sagi[38]	50	18 simple, 32 complex	Matta	35 anatomic, 11 imperfect, 4 poor
2010	*The Bone & Joint Journal*	Tannast[39]	60	33 simple, 27 complex	Matta	50 anatomic, 4 unsatisfactory
2011	*The Bone & Joint Journal*	Briffa[40]	161	65 simple, 96 complex	Matta	119 anatomic, 19 imperfect, 23 poor
2011	*Injury*	Rommens[41]	77	59 simple, 18 complex	Matta	75 anatomic/imperfect, 2 poor
2011	*Formosan Journal of Musculoskeletal Disorders*	Lee[42]	16	16 simple	Matta (not cited)	9 anatomic, 5 imperfect, 2 poor
2011	*Injury*	Laflamme[43]	21	6 simple, 15 complex	Matta	11 anatomic, 8 imperfect, 2 poor
2012	*Journal of Orthopaedic Trauma*	Borg[44]	136	52 simple, 84 complex	Matta	106 anatomic, 23 imperfect, 7 poor
2012	*Journal of Orthopaedic Trauma*	Jeffcoat[45]	41	1 simple, 40 complex	Matta	17 anatomic, 19 imperfect, 5 poor
2012	*Journal of Orthopaedic Trauma*	Kazemi[46]	28	14 simple, 14 complex	Matta	18 anatomic, 8 imperfect, 2 poor
2012	*Journal of Orthopaedic Trauma*	Mitsionis[47]	19	19 simple	Matta	15 anatomic, 3 imperfect, 1 poor
2013	*Journal of Orthopaedic Trauma*	Archdeacon[48]	39	7 simple, 32 complex	Matta	20 anatomic, 14 imperfect, 4 poor
2013	*International Orthopaedics*	Liu[49]	29	14 simple, 15 complex	Matta	24 anatomic, 4 imperfect, 1 poor
2013	*ISRN Orthopedics*	Ma[50]	60	12 simple, 48 complex	Matta	29 anatomic, 22 satisfactory, 9 unsatisfactory
2013	*Journal of Orthopaedic Trauma*	Ruchholtz[51]	26	19 simple, 7 complex	Matta	20 anatomic, 6 satisfactory
2013	*Journal of Orthopaedic Research*	Zha[52]	86	32 simple, 54 complex	Matta	51 anatomic, 35 imperfect/poor
2013	*ISRN Orthopedics*	Aly[53]	12	3 simple, 9 complex	Matta (not cited)	8 anatomic, 2 imperfect, 2 poor
2013	*Injury*	Bastian[54]	43	9 simple, 34 complex	Matta	31 anatomic, 8 satisfactory, 4 unsatisfactory
2014	*International Orthopaedics*	Abo-Elsoud[55]	53	10 simple, 43 complex	Matta	44 anatomic, 6 imperfect, 3 poor
2014	*Injury*	Li[56]	57	57 simple	Matta	55 anatomic, 2 imperfect/poor

no description on how measurements were taken in the original article.[60] The reduction criterion described by Letournel and Judet is based on restoration of normal radiographic landmarks on the 3 Judet radiographs.[74,75] No further description of what is acceptable restoration of these landmarks is available.

Borrelli et al published a very descriptive technique, including figures, of how to reproducibly measure steps and gaps in the articular surface of the fractured acetabulum.[9] This group has also demonstrated that this method has excellent intra- and interobserver reliabilities. Park et al[10] have described a similar technique; however, their description is more difficult to interpret, and no figures demonstrating the measurement technique were published. In addition, no measurements of reproducibility were performed.

Although the article did not meet our inclusion criteria because of lack of documentation of time from injury to surgery, Andersen et al[76] describe a method of measuring femoral head and quadrilateral plate medialization. On the anteroposterior view of the pelvis, a line is drawn from the spinous

TABLE 3. No Measurement Technique or Previously Reported Reduction Grading Scale Used

Year	Journal	First Author	Number of Fractures	Fracture Types	Radiographic Outcome Grading Scale Used	Reported Radiographic Reduction Outcomes
1990	*The Bone & Joint Journal*	Heeg[57]	54	36 simple, 18 complex	No	36 congruent, 18 incongruent
1993	*Injury*	Pantazopoulos[58]	52	52 simple	No	40 excellent, 10 satisfactory
1994	*Clinical Orthopaedics and Related Research*	Alonso[59]	59	59 complex	No	59 excellent or good
1994	*Clinical Orthopaedics and Related Research*	Helfet[60]	84	5 simple, 79 complex	No	76 satisfactory
1994	*Clinical Orthopaedics and Related Research*	Mayo[61]	163	31 simple, 132 complex	No	93 anatomic, forty <2 mm displacement, thirteen 3–5 mm displacement, three >5 mm displacement, 14 secondary congruency
1994	*Clinical Orthopaedics and Related Research*	Ruesch[62]	89	15 simple, 74 complex	No	48 perfect, 24 near perfect, 15 good, 2 poor
1999	*Clinical Orthopaedics and Related Research*	Liebergall[63]	53	26 simple, 27 complex	No	36 anatomic, 15 good, 2 incomplete
2000	*Injury*	Chiu[64]	72	46 simple, 26 complex	No	59 congruent, 13 noncongruent
2001	*Injury*	Deo[65]	79	28 simple, 51 complex	No	30 anatomic, 33 adequate, 11 poor
2006	*The Bone & Joint Journal*	Kreder[66]	128	44 simple, 84 complex	No	One hundred eight <2 mm displacement, nineteen 3–5 mm displacement, one 6–10 mm displacement
2007	*International Orthopaedics*	Ebraheim[67]	32	32 simple	No	28 anatomic, 4 imperfect
2007	*Injury*	Petsatodis[68]	50	29 simple, 21 complex	No	Thirty-nine <2 mm displacement, eleven >2 mm displacement
2008	*Acta Orthopaedica*	Heineck[69]	21	10 simple, 11 complex	No	11 excellent, 7 good, 2 fair, 1 poor
2010	*Archives of Orthopaedic and Trauma Surgery*	Hong[70]	20	14 simple, 6 complex	No	Maximal gap 0–4 mm
2012	*Injury*	Lin[71]	12	12 complex	No	12 congruent
2013	*Acta Orthopaedica Belgica*	Vikmanis[80]	20	4 simple, 16 complex	no	90% anatomic or satisfactory

process of the L5 vertebral body to the center of the symphysis pubis. The distance from the center of the femoral head or the surface of the quadrilateral plate to the central line is then measured bilaterally. The difference between the fractured and intact sides is used to describe the medialization of the structures. No figures were included in this article to provide examples of these measurements. Interobserver reliability of these measurements was excellent for preoperative radiographs but dropped to moderate for the postoperative radiographs.

One author referenced review of several methods of measuring hip joint congruity of Larson et al[77] in a hip dysplasia population.[54] Larson et al found poor intra- and interobserver reliabilities of these methods, and they have not been described in an acetabular fracture population. It is unclear how these methods were applied to the fracture population in the article by Bastian et al.

Several authors have investigated the role of postoperative computed tomography (CT) in assessing acetabular fracture reduction quality.[9,28,77] Their work demonstrates that CT scans are more accurate at identifying residual articular steps and gaps at the joint surface after surgery when compared with plain radiography. In the largest study, however, Archdeacon et al found that management was changed in only 2.5% of cases based on the postoperative CT scan.[78] The question of if a 2.5% revision rate justifies the increased cost and radiation of routine postoperative CT scans is unanswered. Borrelli et al postulate that a lack of standardization of radiographic measurement techniques may contribute to the discrepancy between plain radiographs and CT scans in judging articular reduction.[9] The current review confirms the lack of standardization in the measurement and reporting of quality of reduction of acetabular fractures. Standardizing the measurement and reporting of radiographic reduction of acetabular fractures may decrease the discrepancy between radiographic and CT-based measurements, which may obviate the need for routine postoperative CT scans.

With few exceptions, the current literature lacks well-described radiographic measurement techniques that allow authors to reliably measure the same thing. Of the methods that have been well described, one was tested for inter- and

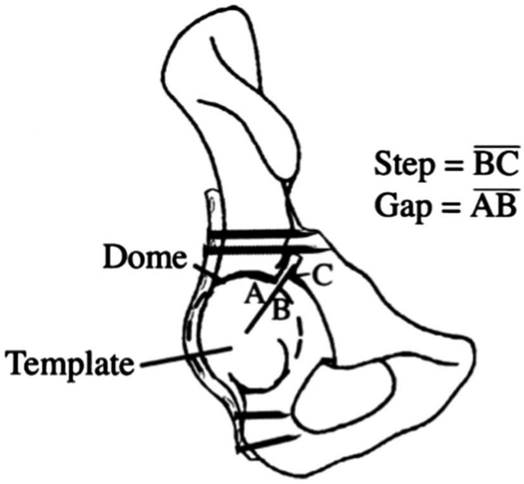

FIGURE 2. Measurement technique of Borrelli et al. Reprinted with permission from Borrelli et al.[9] Copyright © 2005, Wolters Kluwer.

intra-observer reliabilities but none have been tested for validity against functional patient outcomes in the setting of acetabular fractures. Steps in the articular surface, and hip incongruence, are widely accepted to affect patient outcome.[3,6] For instance, Anglen et al[79] have made a good argument that femoral head medialization with superomedial dome impaction is also related to patient outcomes, at least in the elderly population, although this was not supported by reproducible measurement techniques. From a strictly scientific perspective, the impact of any of these anatomic disturbances remains unknown. Intuitively, residual incongruity in the weight-bearing dome of the acetabulum should have the largest effect on patient outcome and therefore would be the most important area to measure radiographically. Therefore, it would follow that the ideal measurement technique would likely focus on the weight-bearing dome and congruity of the acetabulum when assessing the quality of reduction.

To move the science of acetabular fracture treatment decision making and assessment forward, it is important that we begin to standardize methods of measurement of radiographic displacement in acetabular fractures. Once a standardized set of measurements is developed, reliability testing must be performed to ensure that we can trust measurements taken by different authors. Only then should we move forward by correlating these measurements with patient outcomes. Going through these steps will allow us to develop scientific evidence to guide treatment of these injuries, compare future treatments, and provide accurate prognostic information to patients. It will also assure us that outcomes reported in the literature can be compared across studies.

One of the obvious challenges in this process is in the heterogeneity of fracture types and associated bony displacement. Clearly, the previously described measurement techniques reviewed here can be applied to some, but not all, acetabular fracture types. As such, research in the area of radiographic outcome measurement in acetabular fractures could be onerous, both in the complexity of individual injuries and in the diversity of injury types.

The main limitation of our review is in managing the volume of literature our search produced. Our inclusion and exclusion criteria were designed to capture all orthopaedic literature relating to radiographic outcomes of acute surgically managed acetabular fractures; however, some important articles still can be missed. Our inclusion criteria are meant to capture all the orthopaedic literature. Exclusion of sources other than orthopaedic and trauma journals was needed to eliminate articles focusing on acetabular fracture management by other services (eg, percutaneous interventions by radiologists). Any measurement techniques that are published in non-English languages have also been excluded. In reviewing more than 100 articles for assessment of inclusion, we believe that we have not missed any important articles that describe radiographic measurement techniques.

The current standard in literature dealing with the radiographic outcomes of acetabulum fractures lacks even basic description with few exceptions. This makes comparing between series, and treatment options, using these outcomes impossible. Substantial further research in this area is needed, starting with testing of the reproducibility of the techniques identified in this review. Only when well-described techniques have been tested for reproducibility is testing for validity, or importance to functional outcome, possible.

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